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OCTOBER, 1928

Manufacturers' Division Exposition

of

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of the

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What Safety Means to a Quarry Executive*

BY JOHN RICE, *President,*
General Crushed Stone Company, Easton, Pennsylvania

Editor's Note: Speaking from an executive experience which covers over forty years, Mr. Rice, in the following article, has contributed some very valuable thoughts on the subject of safety as seen from the point of view of the quarry executive. Organized safety throughout the quarrying industry should begin with the executive and to be successful must do so. This article is therefore particularly commended to executives for the very careful reading which it justly deserves. It contains much that should be inspirational and helpful.

I HAVE been invited to speak to you on the subject of "What Safety Means to a Quarry Executive." I am going to talk to you very informally without burdening you with a lot of statistics, first because they are uninteresting, and second because the General Crushed Stone Company with which I am connected has not been practicing scientific safety methods long enough to make comparison with past performance illuminating.

Perhaps my personal experience outlining the gradual evolution of thought about safety is quite typical of the growth of the movement among executives and students of human engineering generally, and this is my excuse for using it as the basis of this address.

There was a marked contrast in the relationship of the employer and employee during the past, let us say, seventy years with the antecedent time. In the early days before the time of large corporations, employers were individuals or partners directing a comparatively few men. Prior to the Civil War much of the work was done by slaves and bond servants. The more intimate contacts and simpler character of the service performed together with the fewer number of individuals involved in the first instance and the self-interest inherent in slaves and bond servants in the second instance did result in some personal interest in the welfare of labor.

*Presented before the Quarry Section at the Seventeenth Annual Safety Congress, New York City, October 1 to 5, 1928.

However, with the growth of corporations, with no personal contacts between executives and large aggregations of labor, with the introduction of machinery, with the opportunity to replace the waste due to accidents, sickness and death from immigration and from a prolific native stock, with the fierce struggle of pioneering business enterprises for financial success regardless of ways and means, little heed was given to the welfare of employees from a humanitarian standpoint and no conception of the waste from an economic one.

Executive Experience Covers Forty Years

My personal executive experience covers a period somewhat over forty years. The first ten years were for the most part devoted to general contracting and I was in quite close contact with my men. I was not by nature very hard hearted and had an emotional sensitiveness to human suffering, but I cannot recall that I had any great concern about my men's welfare or safety and certainly no well defined policy or principle concerning it. Employers liability insurance covered the risk and that was all there was to it.

During this period, however, I became aware of the instinctive willingness of men to risk life and limb, when by reason of some accident or other untoward circumstances, structures, machinery or property of any kind were in jeopardy, by rushing to its rescue, regardless of the danger. It was also quite obvious that men often took unnecessary, perhaps reckless risks in the regular course of their work to expedite its accomplishment which otherwise would frequently have added to the cost of same. What I am emphasizing here is not my approval or admiration of such conduct but the evidence of men's willing cooperation notwithstanding the danger and resulting physical penalties.

Under the then existing law, drawn largely in the interest of the employer, the defense of contributory negligence and the act of a fellow workman were usu-

ally adequate to deprive a workman of any redress for accidents sustained by him.

In view of my observations just presented this seemed a rank injustice and led me and my associates to abandon the carrying of liability insurance, when in connection with a contract for ballasting the Lehigh Valley Railroad we entered into the crushed stone business about thirty years ago. We set up a reserve approximately equal to the insurance premiums and paid the men from this reserve their expenses and lost time resulting from accidents on the theory that a business ought to be charged with this expense and not the men themselves. Parenthetically, this was of course the grounds for the passage of the later Workmen's Compensation Acts.

Whether as the result of this policy of intended justice and fairness or not it is interesting to note that we have never had but one law suit with any of our employees as the result of an accident and that one we won.

As a further evidence of added and growing interest in our men some ten years ago we inaugurated a profit sharing system through which our men ratably benefit in our success.

Group Insurance

Moved by a continued regard for the well being of our men, a few years ago we effected a plan of group insurance carrying from $500 to $1,500 per capita according to a wage classification and paid for by the company, further increased by a plan which is partly paid for by the men themselves. This group insurance now amounts to nearly $1,000,000.

The purpose of reciting these acts of modest generosity or enlightened selfishness as they may appear is not to exploit our virtues but to point out that notwithstanding a fairly well advanced theory of the relationship of employer to employee during all these thirty years, not until within the last three or four, did we even give any study or analysis to a definite policy of systematic safety either from a humane or economic standpoint. We really gave little thought as to how and why accidents might and should be avoided. It was the persistent efforts of those interested in the National Safety Council which awakened our vision to the fact that we were overlooking a matter of great importance which was doubtless quickened by our recent adoption of the plan of self-insurance instead of through the various insurance companies otherwise now required by law.

Definite Safety Plan Developed

We began a thorough study and research in this movement with the result that we formed a definite organization charged with the responsibility of carrying these theories into practice.

This plan consists of a general committee made up of the executives and assistants in the main office together with a new officer entitled Supervisor of Insurance and Safety. At each plant is established a committee with the superintendent as chairman. These plant committees meet frequently to confer with the main office committee and also locally to discuss practices and plans. At some plants they meet in the evening to avoid distraction by their current duties, being allowed their regular hourly rate of pay as though at their regular jobs. This has the effect of making the men take the purpose more seriously and thoughtfully.

Of course, one of the greatest difficulties is impressing the men with the seriousness and importance of the work. Their first reaction is that they can take care of themselves and resent the suggestion of a nurse's solicitude for their welfare. Upstanding two-fisted men like to take a chance, they like the dramatic, the sensational and as I have already observed there is an instinctive impulse to do the helpful thing regardless of danger to themselves.

However, the appeal to them that the idea is not born of a maudlin sentimentalism, but on the one hand to avoid suffering and loss to them and their families and on the other hand the loss to the company through the displacement of a skilled or trained employee, the direct expense of the accident through compensation and the indirect loss due to stoppage of work and demoralization of other employees.

Posters Used Effectively

One method of arousing and holding the interest of the men is posting on a conspicuous bulletin board the striking posters of the National Safety Council. In order to further attract the men to these posters we have subscribed to a news service which gives the latest information as to events most likely to interest men of our class, similarly posted on the bulletin board. By their inspection of the lessons borne home to them by these posters, they are influenced by the injunction of the Pennsylvania Supreme Court to "Stop—Look—Listen."

It is but a step to further impress upon the employees the necessity and desirability of prevention of accidents to machinery and property as well as to life and limb.

(*Continued on page 9*)

Relation Between the Standard Abrasion Tests for Stone and Gravel*

REPORTED BY D. O. WOOLF, *Assistant Materials Engineer,*
Division of Tests, United States Bureau of Public Roads

THE majority of the State highway departments in their specifications for concrete permit the use of either crushed stone or gravel as aggregate and give certain requirements for each material in an attempt to obtain materials of comparable quality. The quality requirement most frequently mentioned is the percentage of wear as determined by the Deval abrasion test. It has frequently been stated that a stone with a percentage of wear of 5 is of the same quality as a gravel with a percentage of wear of 15 when considered as aggregate for concrete. In other words, the abrasion loss of stone of a given quality is only about one-third the abrasion loss of gravel of the same quality. There are, however, very little data available with which the above relation may be established.

To obtain information on this important subject a series of tests was begun in the early part of 1926. A sample of rock was tested by the standard method, and then the standard gravel abrasion test was made on rounded particles prepared from the same rock sample. Several such tests were made on rock received as routine samples, the rounded particles being prepared in the Deval abrasion machine. The results of these tests are shown in Table 1.

TABLE 1.—*Abrasion tests on rock and synthetic gravel*

Source of rock	Material	Percentage of wear, standard test	Synthetic gravel	
			Percentage of wear	Ratio to standard test
Indiana	Limestone	[1] 11.7	[2] 5.5	0.47
Virginia	Granite	[2] 2.6	[2] 2.7	1.04
Pennsylvania	Sandstone	[3] 5.8	[3] 1.4	.24
Ohio	Dolomite	[2] 11.0	[2] 13.7	1.24
West Virginia	Limestone	[2] 4.0	[2] 6.9	1.72

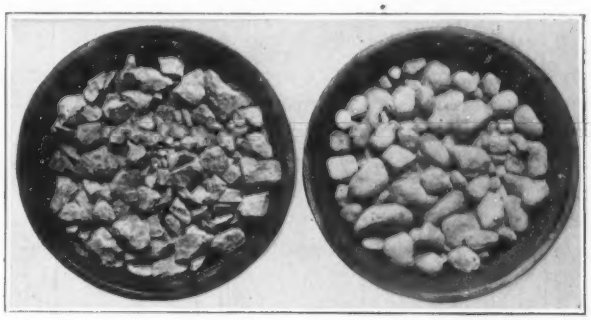
[1] Average of 2 tests. [2] Average of 4 or more tests. [3] Only 1 test.

Abrasion Tests on Rock and Synthetic Gravel Yield Unexpected Results

In the summer of 1927 the use of the brick rattler machine to round off rock particles into gravel shape was suggested. This proved to be a satisfactory method, and 13 large samples of crushed and solid rock were obtained for test. The physical characteristics of these rocks as determined by routine tests are shown in Table 2.

*From *Public Roads* Vol. 9, No. 7, September 1928.

In the instructions regarding sampling it was requested that the ledge rock submitted be taken from the material being supplied to the crusher. This, it was believed, would tend toward obtaining both solid and crushed rock of the same quality. In all cases it was stated that the ledge rock had been so selected.



A SAMPLE OF CRUSHED STONE AND SIMILAR STONE CONVERTED INTO SYNTHETIC GRAVEL

The material obtained furnished an opportunity to investigate also the effect of using crushed rock instead of hand-broken pieces in the standard abrasion test.

TABLE 2.—*Physical characteristics of rock as determined by routine tests*

Identification No.	Location	Name of material	Specific gravity	Absorption	Percentage of wear	Hardness	Toughness
				Per cent			
1	Ohio	Dolomite	2.63	1.82	7.4	8.3	5
2	West Virginia	do	2.84	.15	4.5	14.7	11
3	Ohio	do	2.72	.97	4.7	17.0	8
4	New York	Dolomitic marble	2.76	.08	4.9	18.0	7
5	Ohio	Dolomite	2.54	2.54	6.1	7.0	4
6	do	Limestone	2.53	2.08	8.1	.7	4
7	do	Dolomite	2.42	2.80	19.7	(1)	3
8	do	do	2.49	2.84	4.1	15.3	14
9	Texas	Limestone	2.43	1.69	8.7	2.7	4
10	Ohio	Dolomite	2.73	.70	6.3	9.7	6
11	Texas	Limestone	2.71	.17	4.4	14.7	5
12	Kansas	Argillaceous limestone	2.49	2.52	7.0	11.3	4
13	do	Limestone	2.29	5.26	8.9	.0	4

[1] Specimens satisfactory for this test were not obtained.

It is known that the crushed material is sometimes used in the standard abrasion test in spite of the test specifications, which definitely state that only hand-broken particles shall be used. It is also frequently desirable to test crushed rock sampled from stock piles on the job to obtain some idea of its quality, and it

was believed that this phase of the investigation should be considered.

TABLE 3.—*Abrasion tests of rock and synthetic gravel*

Identification No.	Material	Location	Percentage of wear		
			Standard	Standard crushed	Gravel rounded
1	Dolomite	Ohio	7.4	6.6	4.6
			7.0	6.9	3.6
			7.6	7.3	3.9
			7.3	7.1	4.1
2	do	West Virginia	7.6	6.5	4.0
			4.2	4.3	2.1
			4.4	4.2	2.2
			4.4	4.2	1.8
			4.7	4.4	1.5
3	do	Ohio	4.6	4.1	1.4
			4.6	3.5	1.4
			5.0	3.5	1.7
			4.6	4.0	1.4
			4.4	4.2	1.6
			4.8	3.8	1.8
			5.4	4.4	3.3
4	Dolomitic marble	New York	5.0	4.4	3.1
			4.7	4.2	2.3
			4.7	4.4	.....
			4.8	4.6	.....
			5.9	5.6	4.7
5	Dolomite	Ohio	6.2	6.2	5.2
			5.7	7.2	5.4
			6.8	6.3	4.2
			6.0	6.7	.....
			7.6	7.6	23.4
6	Limestone	do	8.4	7.1	24.2
			8.0	7.3	20.1
			9.0	7.8	22.0
			7.6	7.7	23.1
7	Dolomite	do	20.1	14.6	15.6
			19.5	14.5	12.8
			20.3	17.0	12.9
			19.1	13.0	.....
			19.7	15.0	.....
8	do	do	4.6	4.0	3.4
			3.7	4.4	3.5
			4.0	3.7	3.6
			3.9	4.0	3.2
			4.1	4.5	3.4
9	Limestone	Texas	8.4	10.6	7.2
			8.8	12.8	6.6
			9.2	13.7	4.6
			8.9	9.4	5.8
			8.1	10.1	5.0
			.....	.....	6.7
10	Dolomite	Ohio	6.2	6.2	.....
			7.0	6.2	.....
			6.0	5.9	.....
			6.2	6.2	.....
			5.9	6.1	.....
11	Limestone	Texas	4.2	4.0	1.4
			4.4	4.0	1.7
			4.4	3.7	2.2
			4.3	3.7	1.3
			4.6	3.5	1.9
12	Argillaceous limestone	Kansas	7.5	6.4	7.8
			7.2	6.1	7.8
			7.1	6.0	7.3
			6.4	6.4	7.0
			7.0	6.3	8.5
			9.5	8.0	7.2
			9.6	7.3	7.4
13	Limestone	do	10.0	.....	6.1
			7.0	.....	8.2
			8.6	.....	7.4

Upon receipt of the samples, abrasion tests were made by three methods:

1. Standard method for rock, using cubical pieces broken by hand from ledge rock.[1]
2. As above, except that crushed rock was used.
3. Standard method for gravel, using particles of rock artifically rounded into gravel shape.[2]

In the tests made with crushed rock, samples containing 50 pieces of approximately constant size and weighing 5,000 grams were used. The results of these tests are shown in Table 3 and are summarized in Table 4. A few tests of the same character have also been made on samples submitted for routine examinations. The results are shown in Table 5.

TABLE 4.—*Average results of the abrasion tests using the three methods of testing*

Identification No.	Percentage of wear, standard test	Test of crushed rock		Gravel rounded	
		Percentage of wear	Ratio to standard test	Percentage of wear	Ratio to standard test
1	7.4	6.9	0.93	4.0	0.54
2	4.5	4.2	.93	1.8	.40
3	4.7	3.8	.81	1.6	.34
4	4.9	4.4	.90	2.9	.59
5	6.1	6.4	1.05	4.9	.80
6	8.1	7.5	.93	22.6	2.79
7	19.7	14.8	.75	13.8	.70
8	4.1	4.1	1.00	3.4	.83
9	8.7	11.3	1.30	6.0	.69
10	6.3	6.1	.97	.....	.....
11	4.4	3.8	.86	1.7	.39
12	7.0	6.2	.89	7.7	1.10
13	8.9	7.6	.85	7.3	.82

TABLE 5.—*Comparison of abrasion tests of rock using handbroken and crushed fragments*

Material	Location	Handbroken rock, percentage of wear	Crushed rock	
			Percentage of wear	Ratio to standard test
Siliceous dolomite	Maryland	4.2	2.7	0.64
Do	West Virginia	5.6	4.0	.71
Serpentine	Maryland	4.5	3.8	.84

Following the above tests, samples of from 100 to 150 pounds of graded crushed rock were placed in the brick rattler with an abrasive charge of 200 pounds of ½-inch and 1-inch steel cubes and the machine run until inspection showed that the crushed rock had worn into the semblance of gravel. The rounded material was then tested as specified for the standard abrasion test for gravel. The results of these tests are also shown in Tables 3 and 4.

In comparing the results secured with the rock and gravel abrasion tests a very unexpected relation is presented. It has previously been stated that the general assumption regarding the ratio between the percentages of wear for the abrasion tests of rock and gravel is 1 to 3. The tests reported in this paper show that when a given material of uniform composition is tested by both the rock and gravel abrasion methods the ratio of 1 to 3 is found to be the exception rather than the rule, and that the average ratio as determined by these tests is 1 to 0.86. In other words, with the materials used the loss in the gravel abrasion test is only 86 per cent of that in the rock test.

All of the test results, with one exception, show this general relation, the one exception being sample 6, which gives a ratio of almost 1 to 3. It is possible that

[1] A. A. S. H. O., Tentative Standard Method No. 3, U. S. D. A. Bulletin No. 1216, revised (now in course of publication).
[2] A. A. S. H. O., Tentative Standard Method No. 4, U. S. D. A. Bulletin No. 1216, revised (now in course of publication).

this material is less resistant to impact than is shown by the results of routine tests. (Table 2). A number of rounded particles of samples 6, 12, and 13, which have the same toughness as determined by the routine tests, were tested for resistance to impact with the apparatus devised by F. H. Jackson for testing soft pieces of gravel.[3] The results are shown in Table 6. The reason for the high ratio for sample 6 may be found in the lower resistance to impact of the smaller particles.

Results Indicate Desirability of Modifying or Supplanting Abrasion Test for Gravel

It should be noted that the materials used in these tests were of uniform composition. The results are therefore applicable only to such materials.

The average natural gravel, especially that of glacial origin, is not of uniform composition, and the relation found by the above tests can not be applied to tests of this type of gravel. This nonuniformity in the average gravel emphasizes a fundamental weakness in the gravel abrasion test and raises a question as to the suitability of such a test.

Two samples with the same percentage of wear may vary widely in their suitability for use as a concrete aggregate. A gravel of reasonably uniform quality is more acceptable as an aggregate than another gravel composed of fragments which individually show a wide range in resistance to wear but with the same average loss in the abrasion test. The abrasion test as now made does not differentiate between samples of uniform and nonuniform quality, and it is thought that the test should either be modified to determine the uniformity of the material or be supplanted by other tests which do determine this quality.

TABLE 6.—*Impact tests on synthetic gravel*
[Each value is the average of five tests]

Size of particle (inches)	Inches drop at failure		
	Sample 6	Sample 12	Sample 13
½ to ¾	3.0	6.0	5.0
¾ to 1	4.0	6.5	5.5
1 to 1½	6.5	6.0	7.5
1½ to 2	7.0	7.0	7.0

Certain static-load and impact tests to determine the percentage of soft or disintegrated particles in a gravel are now being investigated. These include a static-load test developed by the Iowa State Highway Commission, as well as the impact test referred to above, both of which are described in the U. S. D. A. Bulletin 1216, Revised Tentative and Standard Methods for Sampling and Testing Highway Materials, which is now in course of publication. The percentage of extremely soft or disintegrated fragments, rather than the percentage of wear on the entire sample, may prove to be the essential feature in the selection of a gravel for use in concrete.

The results of the abrasion tests made with crushed rock show that the percentage of wear averages 90 per cent of that for the standard test on hand-broken rock.

[3] See Am. Soc. for Testing Materials Proc., vol. 22, pt. 2, p. 362.

Marked Increase in High-Type Highways

WITH the cooperation of State highway departments, 8,184 miles of Federal-aid highways were improved in the fiscal year 1927-28, and 2,014 miles that had been previously improved by Federal aid were given surfaces of higher type, according to the Bureau of Public Roads, United States Department of Agriculture. This work was done at a total cost of $205,043,784, of which the Federal Government paid $88,056,984, or 43 per cent, and the States paid the balance.

Under supervision of the bureau, 281 miles of National Forest roads were improved, bringing the total improved mileage of these roads to 3,775 miles. The National Forest road system embraces, at present, a total of 13,911 miles.

In the Federal-aid system, there are 187,753 miles of interstate and intercounty highways, of which, on June 30, 71,074 miles had been improved with Federal assistance and 1,285 miles were undergoing stage construction, that is, were being given a higher type of surface than when previously improved with Federal aid.

The 8,184 miles improved in 1928 include 2,182 miles of graded and drained earth roads; 844 miles of sand-clay; 1,836 miles of gravel; 92 miles of waterbound macadam; 464 miles of bituminous macadam; 136 miles of bituminous concrete; 2,533 miles of Portland cement concrete, and 42 miles paved with vitrified brick. There were 54 miles of bridges and approaches.

Federal-aid highways are the most heavily traveled in the country. Increased demands of a growing traffic are shown by the greater increases in the types more suitable for heavy traffic. The mileage of high types of pavements built, such as bituminous macadam, bituminous concrete, Portland cement concrete, and vitrified brick, increased 19 per cent in 1928, while the mileage of low types, such as waterbound macadam, gravel, sand-clay, and graded and drained increased about 9½ per cent.

Discussion of Mr. Woolf's Paper

By A. T. Goldbeck, *Director,*
Bureau of Engineering, N. C. S. A.

THE foregoing report by D. O. Woolf of the Bureau of Public Roads should attract the interest of users and producers of aggregates and should be of particular value to those who write specifications for aggregates used in concrete highway construction.

The Deval Abrasion Test has long been the standard for determining the quality of crushed stone and although it was originated to test stone for macadam roads, it is now almost universally employed as a measure of quality of stone for other types of construction including Portland cement concrete. If an abrasion test is suitable for stone, it is logical to assume that it is likewise suitable for other types of coarse aggregates, including gravel and slag.

The Deval Abrasion Test

A sample of 50 pieces of hand-broken stone weighing 5 kilograms is subjected to 10,000 revolutions of a 20x34 cm. cast iron drum within a period of 5 hours. The drum is inclined at 30° to the horizontal and the specimen thus falls twice at each revolution from one end to the other. Rounding off the corners of the individual pieces is the effect of this action and the abraded material which passes a 16-mesh sieve is considered as lost during the test. The percentage of wear then equals $\frac{100 \times \text{weight lost}}{\text{original weight.}}$

The French coefficient of wear is calculated by dividing 40 by the percentage of wear.

As above stated, the main effect of this test is to round off the corners and edges of the pieces of rock and also in exceptional cases, especially when the stone is very soft, shattering of some of the fragments may take place.

The Gravel Abrasion Test[1]

Gravel as a rule is naturally round in shape and if tested in the same manner as stone it would show a relatively low loss because most of the wear in the stone sample takes place along the edges. The Gravel Abrasion Test therefore differs from the Deval Abrasion Test for stone. The gravel sample consists of the following sizes:

1250 grams	2 — 1½
1250 grams	1½— 1
1250 grams	1 —¾
1250 grams	¾ —½

[1] Recently a modification of the Gravel Abrasion Test has been made, primarily because of the difficulty of always obtaining a gravel sample complying with the above requirement for size.

In addition to the above sample, 6 cast iron spheres each weighing 0.95 pounds are used as an abrading agent.

Comparison of the Tests

Engineers set definite Deval abrasion test limits for stone with the idea of thus limiting its permissible quality and when gravel is used for a like purpose as stone it is reasonable that their respective physical qualities be about equal. Since the Deval Abrasion Test for stone and the Gravel Abrasion Test differ in technique, there is only one way to determine what the respective test limits should be, namely, to first convert the stone into rounded fragments, thus producing an artificially manufactured gravel and then subject this specimen to the Gravel Abrasion Test. The result thus obtained is then compared with the result of a standard Deval Abrasion Test made on an identical sample of hand broken stone. This procedure was carried out with a number of rocks of different kinds with the surprising result that the Gravel Abrasion Test is found to be only 0.86 as severe as the standard Deval Abrasion Test.

Significance of the Results

This result is all the more surprising when viewed in the light of the general run of highway specifications. Mr. Woolf's tests, wherever they are applicable, certainly show that a smaller percentage of wear should be required for gravel than for stone in the ratio of 86 to 100. Thus if 7.0 per cent wear is permissible for stone in the Deval Abrasion Test, only 6.0 per cent wear should be permitted for gravel, as determined by the Gravel Abrasion Test. Yet actually it is the usual practice to allow gravel to have a percentage of wear of 10.0, 12.0 or 15.0, while stone is rarely allowed for use which has a percentage of wear in excess of 7.0. This state of affairs probably arose because hitherto the test limits have been more or less arbitrarily chosen on the assumption that materials of like quality were being specified.

For the first time we now have a comparison of the respective tests for stone and gravel. The indications from these tests are very strong, that gravel, to be of the same physical quality as stone actually must have a smaller percentage of wear instead of the very much larger percentage now so universally permitted by specifications.

Tests Conducted on Various Mineral Fillers for Sheet Asphalt at the University of Michigan

IN the Proceedings of the Fourteenth Annual Conference on Highway Engineering held at the University of Michigan, Ann Arbor, Michigan, February 14 to 17, 1928, there appears a technical paper which should be of very great interest to all stone producers who are manufacturing dust for use as an asphalt filler. This paper, too voluminous for publication in this Journal, is based on one year's intensive work at the University and is entitled, "Mineral Fillers in Sheet Asphalt Paving Mixtures" by Yasuhei Emori, Roy D. Chapin Fellow in Highway Engineering, University of Michigan, and Paving Engineer, Road Bureau of the City of Tokio, Japan.

Herein are presented the most important features of the paper and those interested may no doubt obtain the above mentioned proceedings by writing to the University of Michigan.

The object of the investigation was to determine the relative efficiencies of the various materials which are now used or which have possibilities of being used in the asphalt paving industry. In asphalt mixtures the chief functions of a mineral filler are to reduce the voids and consequently to increase the density and water-tightness, and to reduce the liability to interior displacement. The tests included:

1. Void tests on mineral aggregates and compressed asphalt mixtures.
2. Stability tests.
3. Water absorption tests.

Fillers Used.

The following dusts were investigated:

1. Limestone dust of three degrees of fineness.
2. Silica dust which was a by-product of the plate glass manufacturing industry.
3. Portland cement.
4. Slaked lime.
5. Clay.
6. Celite and Tripoli. These are both diatomaceous earths, one from California and the other from Missouri.

Bank sand from Ann Arbor, Michigan, graded to conform with Clifford Richardson's ideal heavy traffic mixture and Mexican oil asphalt were also employed.

Asphalt mixture specimens were moulded under pressure while heated and were cooled while still under pressure. The final dimensions of the resulting cylinders being 1½ inches in height and 2 inches in diameter. Stability tests were made by means of a penetration machine and the test consisted of determining the depth of penetration of a 0.5 sq. cm. area rod when load was applied for 15 seconds.

The Effect of Various Mineral Fillers and Varying Degrees of Compression in Reducing Voids in Asphalt Paving Mixtures

Water absorption tests were made by determining the gain in weight of the specimens when immersed in water heated to 140° F. The voids in the various mixtures were calculated on the basis of the known weights and specific gravities of the various constituents and of the finished specimens. The results of the tests for voids in the asphalt mixtures with different degrees of compression, as read from the curves given in Mr. Emori's paper were as follows:

TABLE I

Percentage of Voids in Asphalt Mixtures (% dust given below)

Moulding Compression Lbs. per Sq. In.	Silica Dust	Portland Cement	Slaked Lime	Limestone Dust
3000	8.5	7.2	4.1	3.5
4000	6.7	5.7	3.1	2.5
5000	5.0	4.3	2.2	1.6
6000	4.1	3.3	1.2	0.9

In the above mixtures the following percentages of dust were used by weight.

Limestone dust	15.4 per cent
Silica dust	12.5 per cent
Portland cement	13.6 per cent
Slaked lime	12.4 per cent

The idea of the different percentages of dust was to give the same weight of dust passing the No. 200 sieve. In still other tests 15.4 per cent of each of the four types of fillers was used with the following results:

TABLE II

Percentage of Voids in Asphalt Mixtures (15.4 per cent dust)

Moulding Compression Lbs. per Sq. In.	Portland Cement	Silica Dust	Slaked Lime	Limestone Dust
3000	6.2	5.8	4.4	3.5
4000	5.2	4.6	4.3	2.5
5000	4.4	3.8	4.2	1.6

The void reducing effect of the limestone dust in these experiments is very striking. In general, a low percentage of voids in asphalt mixtures is very desirable.

Effect of Various Mineral Fillers and Compressions on the Stability of Mixtures

The stability of the mixtures shown in Table I and Table II, tested by means of the penetration of a rod,

are shown in the following Tables III and IV. In these tables a high penetration indicates low stability.

TABLE III

Stability Tests of Asphalt Mixtures (same mixtures as in Table I)

Penetration of .5 sq. cm. rod in .01 cm.

Moulding Compression Lbs. per Sq. In.	Silica Dust	Portland Cement	Limestone Dust	Slaked Lime
3000	50	38	17	5
4000	27	21	10	3
5000	15	11	7	2
6000	9	7	6	1

TABLE IV

Stability Tests of Asphalt Mixtures (Same mixtures as in Table II)

Moulding Compression Lbs. per Sq. In.	Silica Dust	Limestone Dust	Portland Cement	Slaked Lime
3000	27	17	15	1
4000	13	10	8	0
5000	9	7	5½	0

There is also a discussion in the paper on the "Effect of Amount of Mineral Filler on Voids and Stability of Mixtures" as well as a discussion on the "Fineness of Mineral Filler." Likewise tests were made to determine the "Effect of Calcareous Matter in Mineral Filler," in which limestone dust and silica dust are compared. The following is quoted from Mr. Emori's article:

. . . It appears that, from the standpoint of mechanical effect in reducing voids, the two fillers (limestone dust and silica dust) are not widely dissimilar. However, when the asphalt is used with the silica dust and the voids in the aggregates are computed from the compressed mixtures, it is seen that the voids in the silica dust combinations are far larger than result from the use of limestone dust.

Although the various differences of fineness, grading, shape, etc., between the two fillers, are factors in their respective behaviors, it is believed that the chief reason for the very different results obtained when combined with asphalt is due to their diversity of physical structure.

It seems that asphalt is incapable of as close adhesion to the surface of silicious particles as to those of calcareous material.

Mr. Emori then describes a simple test in which he demonstrates the truth of the above statement.

In discussing the "Structure of Filler Particles" the following statements are made:

The limestone dust has a very irregular shape and its surface is extremely rough and pitted. The superior adhesion of asphalt to limestone dust, and consequently the higher void reducing and stabilizing effects of this material when used as filler, are doubtless due to this characteristic surface texture.

The silica dust has a very different appearance. The particles are sharp-edged, and their surfaces are glassy. To the latter characteristic is due the poor adhesion of the asphalt to the silicious material, and, as developed previously, asphalt films which are not closely adsorbed, cannot satisfactorily function as a lubricant. Hence, silica dust yields mixtures of relatively high voids.

Although Portland cement particles are irregular in shape, their surface texture is not as rough as that of the limestone. Some particles appear hard and somewhat glassy, probably due to the constituent materials, as clay is used in the manufacture. In view of its surface characteristics, asphalt will not adhere as well to Portland cement as to limestone, and this material will be expected to act less efficiently in reducing the voids of asphalt mixtures.

Slaked lime particles possess extremely rough surfaces, appearing like snowballs in the microphotographs. Slaked lime looks softer than limestone dust, and absorbs asphalt readily. Excessive softness and fluffiness are the disadvantages of this material as a filler.

"The Relation Between Bitumen and Filler" is also considered and it is stated that:

The difference in the amount of asphalt required by the limestone and silica dust mixtures to reach the critical points at which the voids spaces are just filled with bitumen may be explained in the following manner. The asphalt does not adhere to the surface of the silica particles as closely as it does to the limestone dust. Therefore, relatively thicker asphalt films are required between the aggregate particles, in order to reduce their voids. The excess asphalt driven from between the aggregates into the void spaces is relatively small in amount, and, consequently, a greater total percentage is required to fill the voids.

Within the range of bitumen contents used, the limestone dust mixture showed the greatest stability with 9.0 per cent asphalt, whereas the 12.0 per cent asphalt mixture gave a maximum degree of stability in the silica dust series. It can be said that generally slightly more asphalt is required by the silica dust mixture to obtain maximum stability, than is necessary when limestone dust is used. This is due to the fact that, on account of the lesser affinity of asphalt for the silicious aggregates, a larger amount of bituminous lubricant is needed to obtain close contact of the aggregate particles.

Effect of Various Fillers on the Water Tightness of Asphalt Mixtures

The effect of various fillers on the water tightness of asphalt mixtures has been determined and the following quotation is taken from Mr. Emori's article:

The first series of tests was made to compare seven types of fillers,—silica dust, limestone dust of three grades of fineness, Portland cement, slaked lime and Tripoli. A set of specimens was made with mixtures containing each filler under a compression of 3,000 pounds per square inch. All of the specimens were made of aggregates conforming to the Richardson grading, and contained 10.5 per cent bitumen.

The water absorption of these specimens was determined after immersion for 1, 3, 7 and 14 days. The results of these tests are plotted in Fig. 20 (not shown here). The water absorption of each specimen increases with the time of immersion, but the nature of the several fillers was found to affect the results materially. It is undoubtedly true that the density of the mixtures largely affects the water absorption, and for purposes of comparison the voids of the specimens are indicated on the curves of the figure.

At the end of two weeks' immersion in water, mixtures in which silicious fillers were used, such as Tripoli and silica dust, absorbed water up to about 7.0 to 8.0 per cent of their weights. Also, they appeared to begin to disintegrate. On the contrary, the limestone dust mixtures absorbed very little water in comparison with the others, and no indications of disintegration

were observed. Figure 21 is a photograph of two specimens, the one on the left containing silica dust, and the other containing limestone dust. These specimens had been immersed in water for the 14-day period. (Note: The photograph referred to shows cracking and swelling of the silica dust specimen and no apparent effect on the specimen containing limestone dust).

The reason for these differences in behavior is considered to be due to the difference in the degree of adhesion of the asphalt to the surfaces of the aggregates. In the silica dust mixture the adhesion of asphalt is not as complete as in the limestone dust mixtures, and, consequently, water more easily penetrates between them.

The paper is summed up with the following conclusions and general comments:

Conclusions which may be drawn from the investigations described in the foregoing are as follows:

1. The principal object of adding filler to the asphalt mixture is to reduce voids, and produce density. Various kinds of mineral filler have very different effects on the voids, both of the mixture and of the contained aggregate. When the same amounts of filler are used, the one composed of calcareous material has a higher void reducing effect than the one composed of silicious material. The former also yields mixtures of greater stability than the latter.

2. The stability of asphalt mixtures, in which the same materials are used, increases with decreased voids, provided the proper amount of asphalt is used. When different aggregates are used, there is no constant or uniform relation between stability and voids in aggregates. With any mineral filler, the voids of the asphalt mixture and in the contained aggregates are reduced by increasing the filler to a certain maximum amount. The stability of the mixture may also be increased in the same manner, but the amount of filler necessary to obtain maximum stability is slightly less than that amount required to produce minimum voids. The degree of void reducing and stabilizing effect of various fillers is quite different, and generally more silicious filler than calcareous filler is required to obtain maximum stability, or minimum voids.

3. The compression under which the specimen is prepared is closely related to the voids in the mixture, and to its stability. Compression is more important when silicious fillers are used, than in other cases. In general, the compaction of the mixture becomes more difficult as the percentage of filler is increased, especially when a fluffy filler is used.

4. When the same amount of filler produced from the same material is used, the one which is finer ground has the higher void reducing effect. The most effective part of the filler is composed of those sizes smaller than 0.05 mm. in average diameter.

5. When asphalt is combined with a calcareous filler, it adheres very closely to the surface of the filler particles, or may be absorbed to some extent. Asphalt does not adhere as closely to the surface of filler composed of silicious matter. Microscopic examination indicates that these differences are due to the characteristic surface structures of the fillers. The affinity which exists between calcareous fillers and asphalt is instrumental in reducing voids in the asphalt mixtures and aggregates, and also contributes to stability.

6. The amount of asphalt used in a mixture greatly affects the voids and stability. The effect of the amount of asphalt varies with the kind of mineral filler employed. Generally, a somewhat greater amount of asphalt is necessary when silicious filler, rather than calcareous filler, is used.

7. The water tightness of mixtures is considerably affected by the nature of the filler. The water tightness of mixtures depends largely upon the density. Therefore, the mineral filler which is more effective in reducing the voids in mixtures, also renders the mixture more watertight.

What Safety Means to a Quarry Executive

(*Continued from page 2*)

The constant dwelling by the committees on all phases of these questions develops in them secondary ideas such as neatness, order and forethought. It results in a place for everything and everything in its place. As leaders learn others follow. The best way to learn is to teach.

Neatness reduces fire hazards by the practice of gathering up inflammable material and having a safe place to dispose of it. Cleanliness of machinery often discloses latent weaknesses which otherwise are only ascertained by a breakdown.

Morale of Men Improved

A questionnaire to our superintendents as to the effect of the movement discloses in their judgment a distinct improvement in the morale of their men, a greater interest in their work and many resulting economies.

As one of them expressed it, they have all come to realize that a trained man on the pay roll was a lot more valuable than on a compensation list.

There is a growing and increasing belief by the men that the company is really interested in their welfare, not sentimentally or piously, but sensibly and wisely.

It is interesting to note that in the Safety Competition inaugurated by the *Explosives Engineer* under the auspices of the United States Bureau of Mines for such quarries in the membership of the National Crushed Stone Association as entered the contest, our White Haven plant won the trophy for 1927, not having had a lost time accident for eighteen months. Our Winchester plant during July had only forty-five minutes lost time as the result of accidents of any nature whatever, men or machinery, which is an admirable record in our experience.

Benefits Cannot Be Measured In Dollars

I cannot reduce to dollars the resultant benefits of this intensive safety movement on our part but I believe it is no exaggeration to say it has effected a saving of ten per cent in our operating expenses and thirty per cent in our accident expense.

The movement is humane, economical and profoundly wise from any point of view and speaks well for the vision, labor and persistance of those pioneers of the National Safety Council in so earnestly keeping at it until it has become impressed upon most executives as a necessity to industrial progress.

The Crushed Stone Journal

J. R. BOYD, Editor

A. T. GOLDBECK, Director, Bureau of Engineering

The National Crushed Stone Association

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Convention Plans Progress

PLANS for the Manufacturers' Division Exposition to be held in conjunction with the Twelfth Annual Convention of the Association at the Hollenden Hotel, Cleveland, January 21 to 24, 1929, are rapidly nearing completion. Final details will be arranged at the Manufacturers' Division dinner meeting at the Hotel Pennsylvania, New York City, on October 26, and immediately after this meeting the exposition circular, giving all necessary information to exhibitors, and application for booth space, will be mailed to all associate members.

The Hollenden Hotel, which was selected as the official headquarters of the convention, offers an unusually attractive layout. The exposition will be housed in the Grand Ball Room and adjoining Lounge Room, which are located on the Mezzanine floor in close proximity to the convention hall where the general sessions will be held. On this same floor are located an abundance of private dining rooms and committee rooms, admirably adapted to our group luncheons and local association meetings, making it possible to confine all of the convention activities to the one floor immediately above the lobby.

Arrangements have been made with the management of the hotel to hold the annual banquet in the main dining room which assures that this event, representing as it does the climax of inspiration and enthusiasm throughout the convention, will be held in the most pleasant surroundings.

The programs of our conventions for the last few years have been prepared under the careful and painstaking guidance of our president, Mr. Graves, and it is no exaggeration to say that he has established an enviable reputation for the Association as regards the interest, value and comprehensiveness of the programs of our annual meetings. Nor will this year be any exception, as, if possible, Mr. Graves is giving even more time and careful thought than previously to the planning of the Cleveland program. It is not possible as yet to give the tentative convention program, but it can be stated with assurance that it will be replete with interesting and valuable discussions dealing with every phase of the crushed stone industry and presented by those who, by virtue of their training and experience, have attained distinction in their respective fields.

No crushed stone producer, no matter how large nor how small, can afford to miss the opportunity presented by this convention of sitting in at the council table of his industry and having a voice in the formulation of the policies of the industry for the coming year, to say nothing of the opportunity afforded for absorbing inspiration and knowledge without measure, tools which are so necessary for the intelligent and forward-looking conduct of our individual businesses.

No convention could be considered entirely successful that did not provide for relaxation and entertainment after the work of the day has been concluded. Those in charge of the Cleveland Convention are sparing no effort to make the entertainment features of our twelfth annual meeting surpass in every way all previous efforts. The ladies in attendance will by no means be neglected, as arrangements are being perfected with the Cleveland Tourist and Convention Bureau which will insure a good time for them from the moment when they arrive until they leave.

Is it not a common mistake to take the annual meeting and all that it implies as too much a matter of course? If possible we arrange to go, but if not, console ourselves with the thought that perhaps it can be arranged next year. But suppose for the moment that there were no National Crushed Stone Association and consequently no annual meeting—there is not one of us who would not feel an irreparable loss, and who would not sorely miss the opportunity to exchange ideas with his fellow producer, to greet again the old friends and make new ones, to snap out of the rut of our routine existence and receive the inspiration and knowledge so helpful and necessary for the healthful and forward-looking growth of our industry.

Does not each and every one of us owe it to himself and to the industry of which he is a part to contribute his utmost to the success of these annual meetings? I most sincerely believe that he does and further, I know of no better way of giving voice to our desire to be helpful or of showing our appreciation of the wonderful work which the president and officers associated with him are accomplishing, in the interests of your business, than by being present at your convention when the gavel falls at Cleveland.

Production of Crushed Stone Continues to Increase

THE production of crushed stone in this country in 1927, according to the United States Bureau of Mines, Department of Commerce, amounted to 94,948,770 short tons valued at $97,474,267, which was an increase of 15 per cent in quantity as compared to the production for 1926. Crushed stone for concrete and road work (78,544,210 tons, valued at $84,177,237) increased 17 per cent in quantity and crushed stone reported as used for railroad ballast (16,404,560 tons, valued at $13,297,030) increased 5 per cent.

Table I shows the sales of crushed stone in 1927 by uses and the sales of 1926 for comparison. Table II shows the crushed stone (including concrete and road metal and railroad ballast, but not including fluxing stone or agricultural limestone) sold or used by producers in the United States in 1927, by states.

TABLE I.—CRUSHED STONE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, 1926 AND 1927, BY USES

Use	1926 Quantity short tons	1926 Value	1927 Quantity short tons	1927 Value
Crushed stone	82,515,560	$87,872,014	94,948,770	$97,474,267
Furnace flux	23,859,390	18,049,012	21,666,070	15,985,525
Agricultural limestone	1,850,620	3,064,235	2,206,470	3,360,704

TABLE II.—CRUSHED STONE SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 1927, BY STATES

State	Short Tons	Value
Alabama	196,020	$113,304
Arizona	(1)	(1)
Arkansas	(2) 411,950	439,228
California	(2) 8,144,400	6,649,277
Colorado	(2) 187,880	87,685
Connecticut	(2) 2,168,070	2,507,189
Delaware	(1)	(1)
Florida	7,382,260	6,041,194
Georgia	(2) 485,850	551,972
Idaho	231,980	271,540
Illinois	7,643,700	6,006,004
Indiana	4,195,280	4,438,846
Iowa	971,730	932,236
Kansas	742,340	824,268
Kentucky	2,422,690	2,397,990
Louisiana	115,450	169,643
Maine	112,320	140,594
Maryland	(2) 985,790	1,454,084
Massachusetts	(2) 2,225,010	3,177,016
Michigan	(2) 1,832,700	1,235,522
Minnesota	(2) 552,790	719,452
Missouri	(2) 2,267,670	2,860,335
Montana	(2) 28,790	27,933
Nebraska	(2) 69,420	70,824
Nevada	(2) 355,600	340,180
New Hampshire	(2) 65,760	81,739
New Jersey	(2) 2,423,410	3,695,462
New Mexico	(1)	(1)
New York	(2) 8,945,410	11,470,964
North Carolina	2,079,850	2,902,998
Ohio	11,323,640	9,907,284
Oklahoma	1,668,120	1,326,585
Oregon	(2) 1,429,640	1,488,273
Pennsylvania	7,295,820	9,251,432
Rhode Island	126,190	259,022
South Carolina	1,164,830	1,632,225
South Dakota	(2) 221,880	271,521
Tennessee	1,751,890	1,809,358
Texas	(2) 2,896,430	1,978,413
Utah	(2) 113,500	116,897
Vermont	(2) 21,020	31,625
Virginia	(2) 2,335,290	2,238,212
Washington	586,350	404,508
West Virginia	(2) 740,120	619,550
Wisconsin	(2) 2,178,510	2,469,652
Wyoming	53,870	48,728
Undistributed	3,075,040	3,277,594
	94,526,260	96,738,358
Hawaii	324,040	576,166
Porto Rico	98,470	159,743
Total	94,948,770	$97,474,267

(1) Included under "Undistributed."
(2) To avoid disclosing confidential information, certain states are slightly incomplete, the figures not included being combined under "Undistributed."

Associate Members of the National Crushed Stone Association

Air Reduction Sales Co., 342 Madison Ave., New York City.
Liquid Oxygen Explosive.

Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Crushing Plants and Machinery.

American Manganese Steel Co., Chicago Heights, Ill.
"Amsco" Manganese Steel Castings.

American Tar Products Co., Union Trust Bldg., Pittsburgh, Pa.
Tar Products for Road Construction and Maintenance.

Armstrong Manufacturing Co., Waterloo, Iowa.
Blast Hole Drills, Bit Dressing Machines.

Atlas Powder Co., Wilmington, Del.
Explosives and Blasting Accessories.

Earle C. Bacon, Inc., 26 Cortlandt St., New York City.
Complete Plants, Crushers, Elevators, Screens, Conveyors.

The Barrett Company, 40 Rector St., New York City.
Tarvia for Road Construction, Repair and Maintenance.

Blaw-Knox Co., P. O. Box 915, Pittsburgh, Pa.
Manufacturers of Steel Products.

The Browning Crane Co., 16226 Waterloo Rd. N. E., Clev., O.
Locomotive Cranes.

C. G. Buchanan Co., Inc., 90 West St., New York City.
Crushers, Crushing Rolls, Magnetic Separators.

Bucyrus-Erie Company, South Milwaukee, Wis.
Shovels—Steam, Diesel, Electric and Gasoline—and Dredges.

Buffalo Wire Works, 521 Terrace, Buffalo, N. Y.
Wire Cloth and Screens.

Burrell Eng. & Constr. Co., 513 W. Jackson Blvd., Chicago, Ill.
Design and Construction.

Canadian Explosives, Ltd., Canada Cement Bldg., Mont'l, Can.
Explosives and Blasting Supplies.

The Carroll Chain Co., 265 Hosack St., Columbus, Ohio.
"Carroll" Solid Weld Steam Shovel Hoisting Chains.

Cement, Mill and Quarry, 101 W. 31st St., New York City.
"Publishers."

Chicago Pneumatic Tool Co., 6 E. 44th St., New York City.
Rock Drills, Air Compressors, Diesel Engines, Pneumatic Tools

Cross Engineering Works, Carbondale, Pa.
Perforated Metals.

Davis and Averill, 28 Fulton St., Newark, N. J.
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The Dorr Company, 247 Park Ave., New York City.
The Dorr Washer.

E. I. du Pont de Nemours & Co., Wilmington, Del.
"Explosives of All Kinds and Blasting Accessories."

Easton Car and Construction Co., Easton, Pa.
Quarry Cars.

Ensign-Bickford Co., Simsbury, Conn.
Safety Fuse and Cordeau Bickford Detonating Fuse.

Fate-Root-Heath Co., Plymouth, Ohio.
"Plymouth" Gasoline Locomotives.

Flexible Steel Lacing Co., 4607 Lexington St., Chicago, Ill.
Alligator and Flexco H. D. Belt Fasteners.

Frog, Switch & Mfg. Co., Carlisle, Pa.
Manganese Steel Castings.

General Electric Co., Schenectady, N. Y.
Electrical Apparatus and Supplies.

Gill Rock Drill Co., Lebanon, Pa.
Blast Hole Drilling and Fishing Tools.

Good Roads Machinery Co., Kennett Square, Pa.
Crushers, Elevators, Elevator Feeders and Revolving Screens

The Goodyear Tire and Rubber Co., Inc., Akron, Ohio.
Belting: Transmission, Conveyor, Elevator; Hose Packing.

Graham Coal Company, Commercial Trust Bldg., Phila., Pa.
Coal and Coke.

Grasselli Powder Co., Cleveland, Ohio.
Manufacturers of Explosives.

Gruendler Patent Crusher & Pulv. Co., 1st & Frk., St. Louis, Mo.
Crushing, Pulverizing, Screening and Conveying Machinery.

Harnishchfeger Corp., 38th & National Aves., Milwaukee, Wis.
Gasoline, Electric and Diesel Shovels—Cranes, Draglines.

The Hayward Co., 50 Church St., New York City.
Hayward Orange Peel and Clam Shell Buckets.

Heisler Locomotive Works, Erie, Pennsylvania.
Geared Locomotives.

The Hendrick Mfg. Co., Carbondale, Pa.
Perforated Metal Screens, Elevator Buckets.

Hercules Powder Co., Wilmington, Del.
Explosives and Blasting Supplies.

C. W. Hunt Co., 1580 Richm'd Terrace, W. New Brighton, N. Y.
Mitchell Electric Vibrating Screen.

Illinois Powder Manufacturing Co., St. Louis, Mo.
Explosives and Blasting Supplies.

Ingersoll-Rand Company, 11 Broadway, New York City.
Rock Drills, Steel Sharpeners, Oil Furnaces and Hoists.

The Jeffrey Mfg. Co., Columbus, Ohio.
Elevating and Conveying Machinery.

Keith Dunham Co., 110 S. Dearborn St., Chicago, Ill.
L. O. X. (Liquid Oxygen Explosive) Loxite Cartridges.

Kennedy-Van Saun Mfg. & Engr. Corp., 50 Church St., N. Y. C.
Kennedy Gyratory Crushers.

Kensington Steel Co., 505 Kensington Ave., Chicago, Ill.
Manganese Steel and Alloy Steel Castings.

Keystone Lubricating Co., Philadelphia, Pa.
Lubricating Greases and Lubricating Devices.

Koehring Company, Milwaukee, Wis.
Gasoline Shovels, Cranes and Draglines.

Koppel Industrial Car and Equipment Co., Koppel, Pa.
Quarry Cars in hand & air operated designs—Track Material.

The Loomis Machine Co., Tiffin, Ohio.
Blast Hole, Prospecting and Drilling Machinery and Tools.

Manganese Steel Forge Co., Richm'd St. & Erie Ave., Phila., Pa.
"Rol-Man" Screens, Chains, Plates and Forged Products.

The Marion Steam Shovel Co., Marion, Ohio.
Power Shovels and Cranes—Steam, Gasoline and Electric.

National Malleable & Steel Cast. Co., 10600 Quincy Ave., Clev, O.
Naco Cast Steel Steam Shovel Chain & Certified Mall'ble Cast.

Niagara Concrete Mixer Co., 40 Pearl Street, Buffalo, N. Y.
"The Niagara Screen."

The Osgood Company, Marion, Ohio.
Power Shovels and Combinations.

Peerless Explosives Co., 22 N. Franklin St., Wilkes-Barre, Pa.
Explosives and Blasting Supplies.

Pit and Quarry, Rand McNally Bldg., Chicago, Ill.
"Publishers."

The H. K. Porter Co., 49th & Harrison Sts., Pittsburgh, Pa.
Locomotive Builders.

Rinek Cordage Co., Easton, Pa.
"Rinek" Reliable Rope.

Robins Conveying Belt Co., 15 Park Row, New York City.
Material Handling and Screening Equipment.

Rock Products, 542 So. Dearborn St., Chicago, Ill.
"Publishers."

The Sanderson-Cyclone Drill Co., Orrville, Ohio.
Drills, Big Blast Hole, Drilling and Fishing Tools.

Sauerman Bros., Inc., 438 S. Clinton St., Chicago, Ill.
Cableway Excavators, Power Scrapers.

The Orville Simpson Co., 1230 Knowlton St., Cincinnati, O.
Screens, ROTEX, level, self-cleaning, 100 to ¾" mesh.

The Stearns Conveyor Co., 200th St. & St. Clair Ave., Clev., O.
Material Handling Machinery.

Stephens-Adamson Manufacturing Co., Aurora, Ill.
Speed Reducers and Belt Conveyor Carriers.

Symons Bros. Co., 111 W. Washington St., Chicago, Ill.
Ore, Rock and Gravel Crushers.

Taylor-Wharton Iron & Steel Co., High Bridge, N. J.
TISCO Manganese Steel Castings.

The Thew Shovel Co., Lorain, Ohio.
Steam, Gasoline and Electric Shovels, Cranes, Draglines.

The Traylor Engineering & Mfg. Co., Allentown, Pa.
Crushing, Cement and Mining Machinery.

Traylor Vibrator Co., 1400 Delgany St., Denver, Colorado.
Vibrating "Screen Supreme."

Troco Lubricating Co., Philadelphia, Pa.
Manufacturers of Petroleum Products.

Trojan Powder Co., Allentown, Pa.
Explosives and Blasting Supplies.

The W. S. Tyler Co., Cleveland, Ohio.
Woven Wire Screens and Screening Equipment.

Union Explosives Co., Clarksburg, W. Va.
Explosives and Blasting Supplies.

Vulcan Iron Works, Wilkes-Barre, Pa.
Steam, Gasoline, Electric Locomotives.

Western Wheeled Scraper Co., Aurora, Ill.
Western Portable Rock Crushers.

George D. Whitcomb Co., Rochelle, Ill.
Gasoline Locomotives.

Williams Patent Crusher and Pulverizer Co., St. Louis, Mo.
Hammer Crushers.

Woodhouse Chain Works, Trenton, New Jersey.
Welded Link Chains—Steam Shovel.